



NDIA

45th Annual Fuze Conference

Design and Development of a new Electronic Time (ET) Fuze for Mortars (XM784/XM785)

18 April 2001

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Tank-automotive & Armaments COMmand

Report Documentation Page

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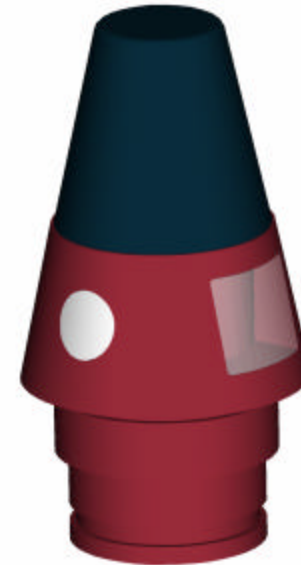


XM784 / XM785

Electronic Time Fuze for Mortars



- Background
- Need
- Requirements Overview
- Programmatic Approach
- Schedule
- Technical Approach





XM784 / XM785 ET Fuze for Mortars

Background



- **No US Fielded ET Fuze for Mortars Exists**
 - **US Requirements Filled By Foreign Source**
 - **M776 / M772 Diehl/Junghans (Germany)**
 - **Under Waiver From US Safety Standards**
- **User Persistently Indicated Need For a US ET Fuze (Since Mid '80's)**
- **No NDI Design Solution Exists**
 - **Foreign Comparative Studies**
 - **Engineering Studies**
 - **Contractor Studies**



XM784 / XM785 ET Fuze for Mortars

Need



- **Army Safety Standards**
 - **No Current Time Fuze Meets Standards**
- **Need For Increased Timing Accuracy**
 - **Poor Fuze Accuracy**
 - **Adversely Effects Cartridge Performance**
- **Three Fuze Types**
 - **PROX: (M734A1 Multi-Option Fuze)**
 - **PD / Delay: (XM783)**
 - **Time: (XM784 (60 / 120 mm) & XM785 (81 mm))**
- **Legacy Fuzes Require a Wrench To Set**
 - **Difficult to Read**
 - **Require External Lighting**
- **Mortar Time Fuze Modernization**



XM784 / XM785 ET Fuze for Mortars

Requirements



- **Safety Per MIL-STD-1316 (Dual Environ Safety)**
- **Cartridge Compatibility:**
 - 60 mm (M721 Illum & M767 IR Illum)
 - 81 mm (M853A1 Illum, XM816 IR Illum & M819 RP Smoke)
 - 120 mm (XM930 Illum, XM983 IR Illum)
- **Hand Settable Required (Inductive Set Desired)**
 - Self Illuminating
- **Accuracy 98%**
- **Set Time 5 – 99.9 Seconds (0.1 Sec Increments)**
- **Cannot Significantly Degrade Cartridge Range**
- **20 Year Shelf Life (Controlled Environment)**



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Programmatic Approach

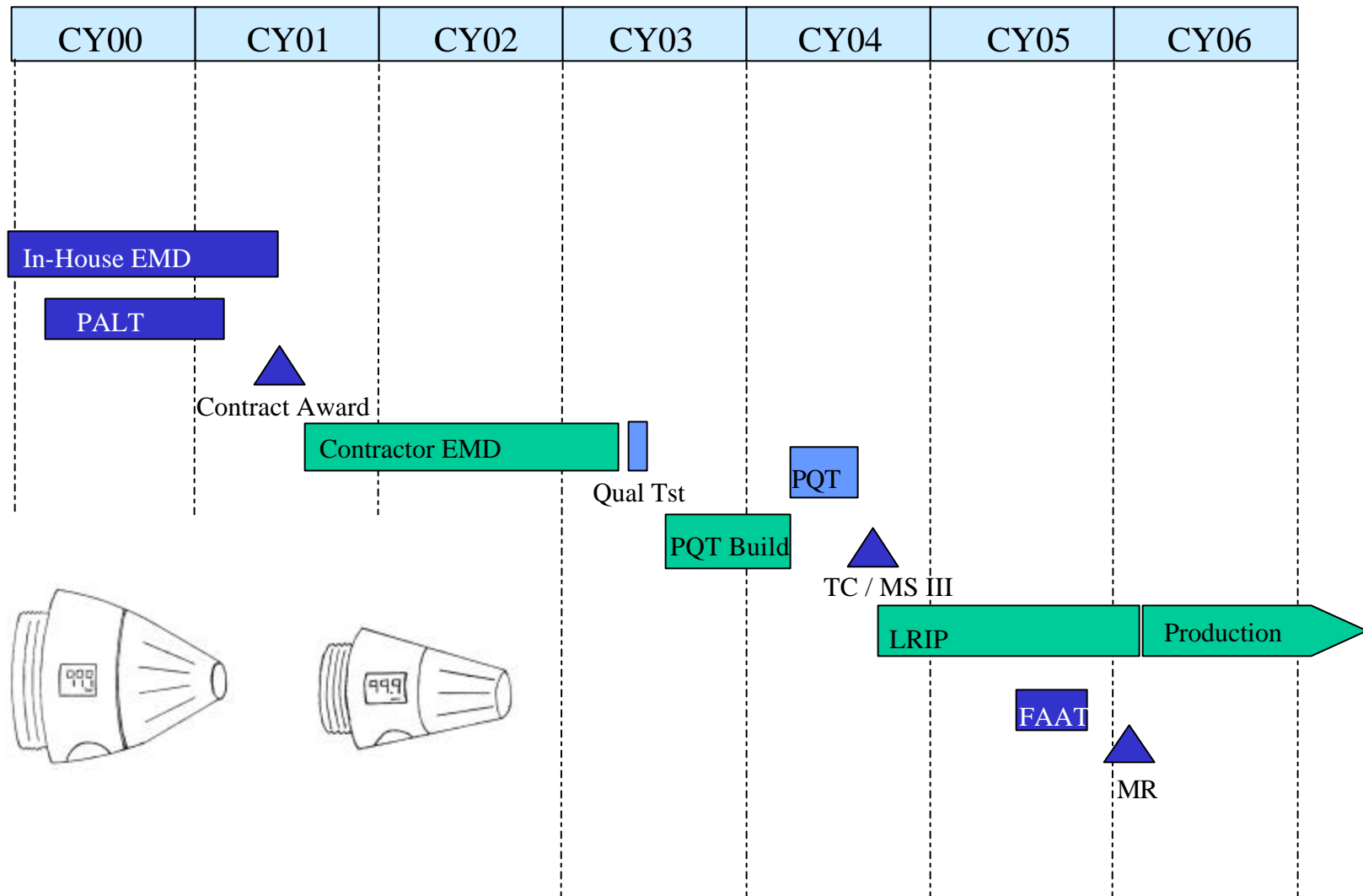


- **Systems Engineering / IPT Approach**
- **Initial Gov't Eng Activity – Risk Mitigation Effort**
- **Solicit Contractor – Competitive / Cost Plus Type**
 - **Phase 1: Develop & Demo Design Solutions (Award Fee)**
 - **Phase 2: Production Qualification / TC (Award Fee)**
 - **Conduct Government Ballistic Tests**
 - **TC Standard**
 - **Phase 3: Low Rate Initial Production (Incentive Fee)**
 - **LRIP Effort (22k – 60k fuzes)**
 - **FAAT**
 - **Three Production Lots to MR**



XM784/ XM785 ET Fuze for Mortars

Schedule





XM784/ XM785 ET Fuze for Mortars

Technical Approach



- **Maximize Use of NDI Components**
 - **Minor Modifications**
- **Initial In-House EMD**
 - **Develop Expertise For Source Selection**
 - **Development / Technology Exploration**
 - **Fuze Electronics**
 - **Power Source**
 - **Pre & Post Launch Battery Solutions**
 - **Non-Battery Solutions**
 - **Safety & Arming Device (incl 2nd Env Sensor)**
 - **Pressure Sensor**
 - **Muzzle Exit Sensor**
 - **Air Flow Sensor**
 - **Explosive Train**
 - **Packaging and Hand Setting**



XM784/ XM785 ET Fuze for Mortars

Electronics



- **Developed a power budget**
- **Evaluated the tradeoffs of an ASIC vs a microcontroller**
- **Designed and fabricated generic surface mount breadboard**
- **Uses a lithium reserve battery (M762 style)**
- **Developed schematic diagrams, safety logic, flow charts, and block diagrams have been developed**
- **Uses an inertial “T₀” switch and impact sensor**
- **Developed logic software for the main and safety microcontrollers**
- **Interfaced the logic software with the breadboard and conducted bench tests**



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Power Supply



- **Studied candidate solutions:**

Electro-chemical

M80
SD Fuze
OICW
M762
Active lithium
thermal

Non-chemical

Piezo-electric
Electro-magnetic
Setback generator
Fluidic generator
Turbine alternator

- **Capacitor cost / performance trade-offs may prohibit non-chemical initiatives**
- **Evaluated both an Evans Capattery and M762 battery for operation with our circuit**



XM784/ XM785 ET Fuze for Mortars

Second Environment Sensor

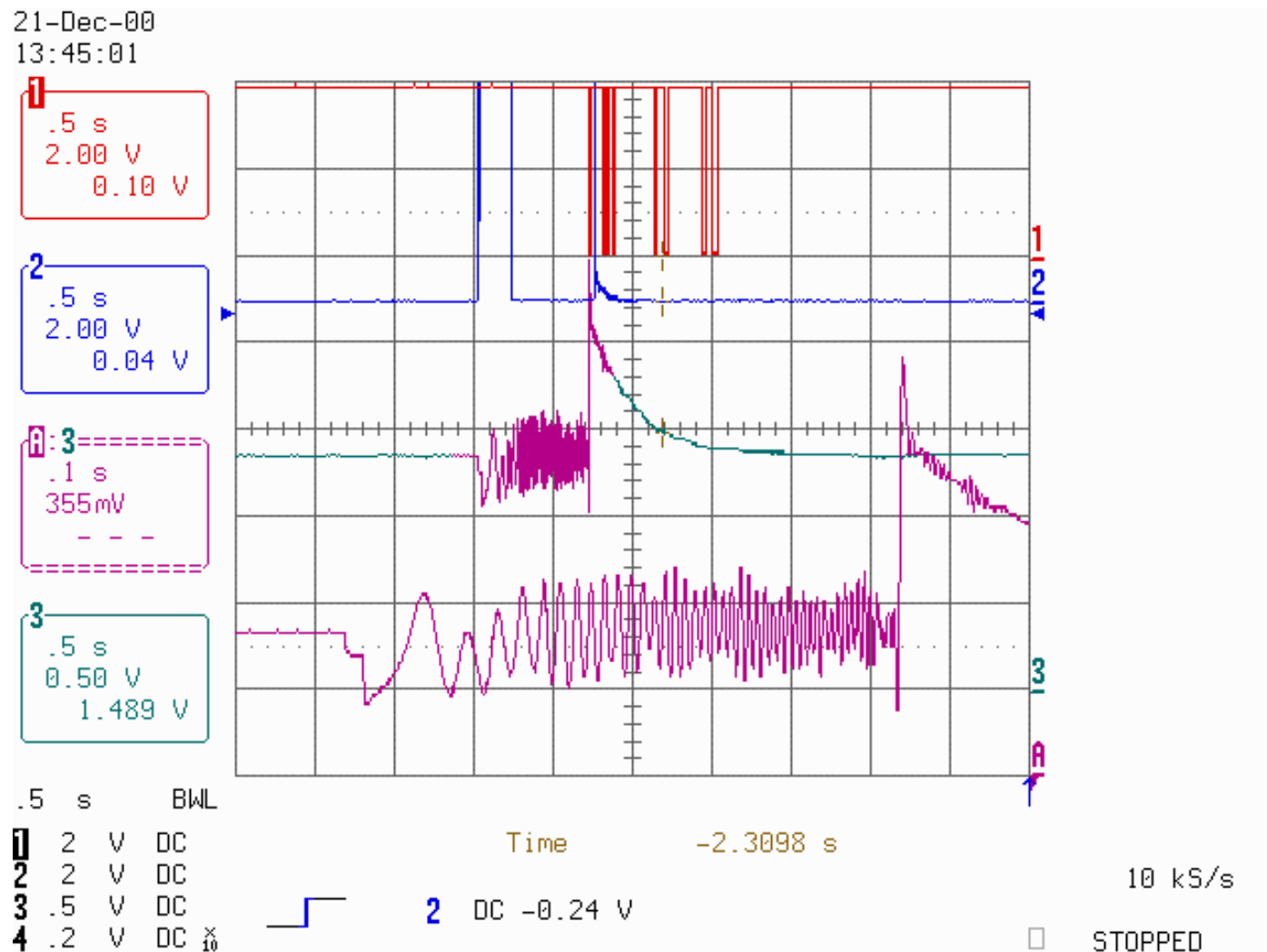


- **Researched several approaches:**
 - Pressure / Force
 - Muzzle Exit (Mag, ESS, RF)
 - Air Flow (Turbine driven lock)
- **Conducted RF sensor free fall drop tests**
 - 60mm, 81mm and 120mm tubes
- **Generated pressure profile plots**
- **Adapted a COTS pressure sensor**
 - Evaluated via laboratory flow-controller tests
- **Conducted aeroballistic tests in wind tunnel**



XM784/ XM785 ET Fuze for Mortars

Second Environment Sensor



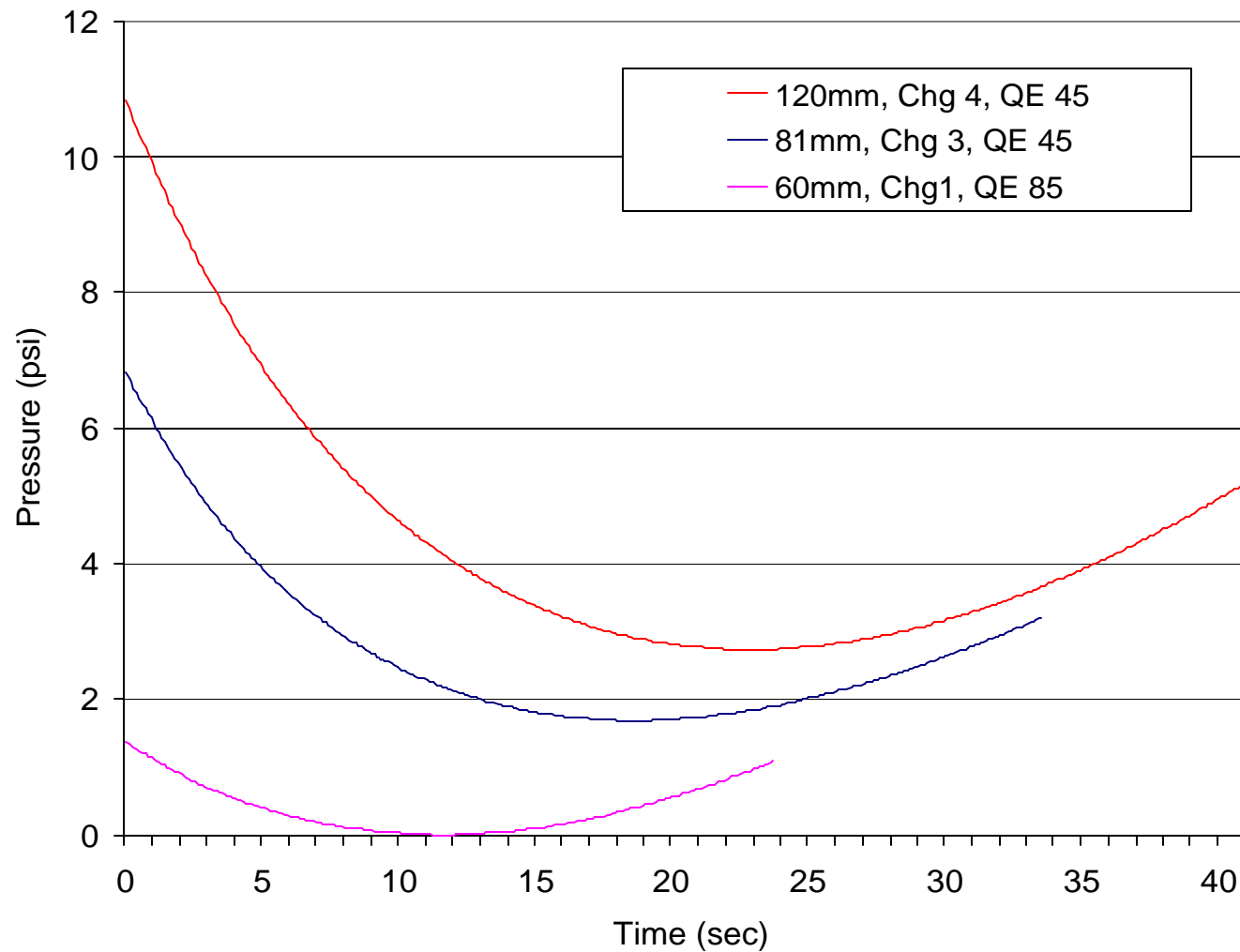


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Second Env Sensor



Calculated Pressure vs Time





XM784/ XM785 ET Fuze for Mortars

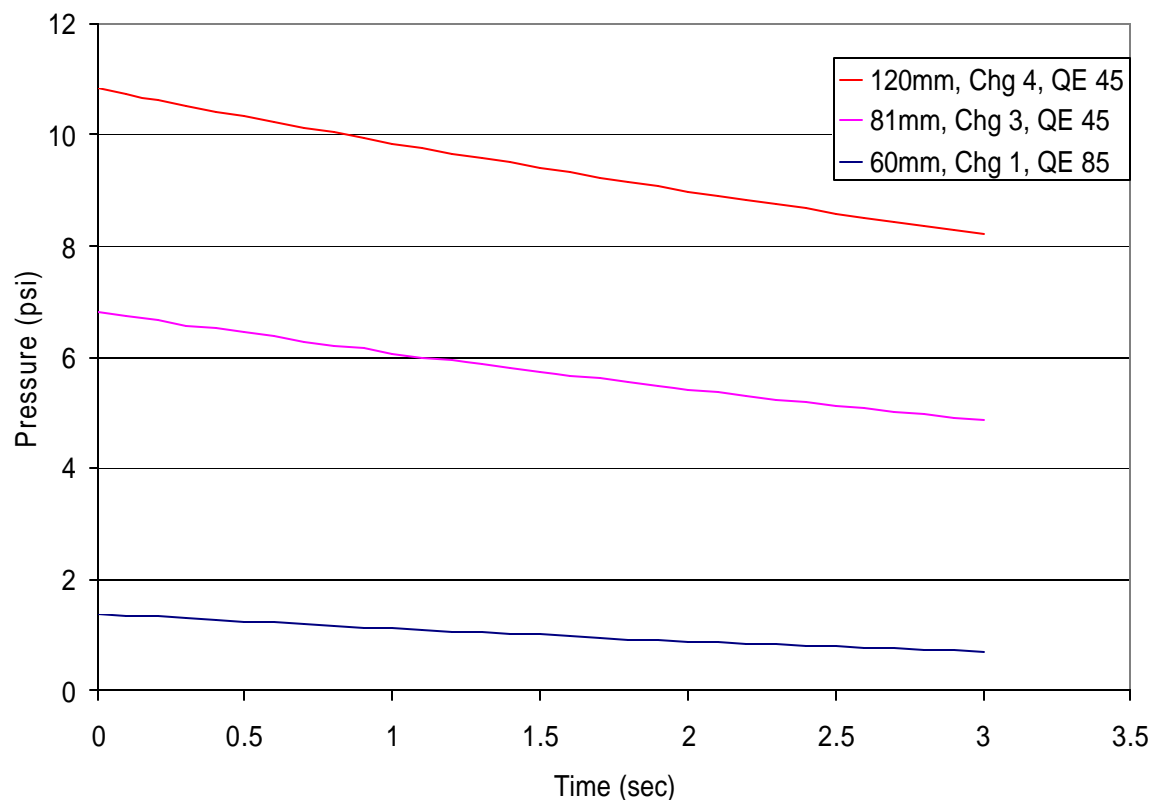
Second Env Sensor



(Calculated Pressure - First 3 secs of Flight)

Calculated Pressure vs Time

| Chg @ QE45 | | Press Range (psi) |
|------------|---|-------------------|
| 60mm | 1 | 1.4 - 0.9 |
| | 2 | 2.7 - 1.7 |
| | 3 | 4.2 - 2.7 |
| | 4 | 5.8 - 3.7 |
| 81mm | 1 | 2.1 - 1.4 |
| | 2 | 4.2 - 3.0 |
| | 3 | 6.8 - 4.8 |
| | 4 | 9.7 - 6.8 |
| 120mm | 1 | 2.5 - 1.8 |
| | 2 | 4.7 - 3.5 |
| | 3 | 7.4 - 5.6 |
| | 4 | 10.8 - 8.2 |



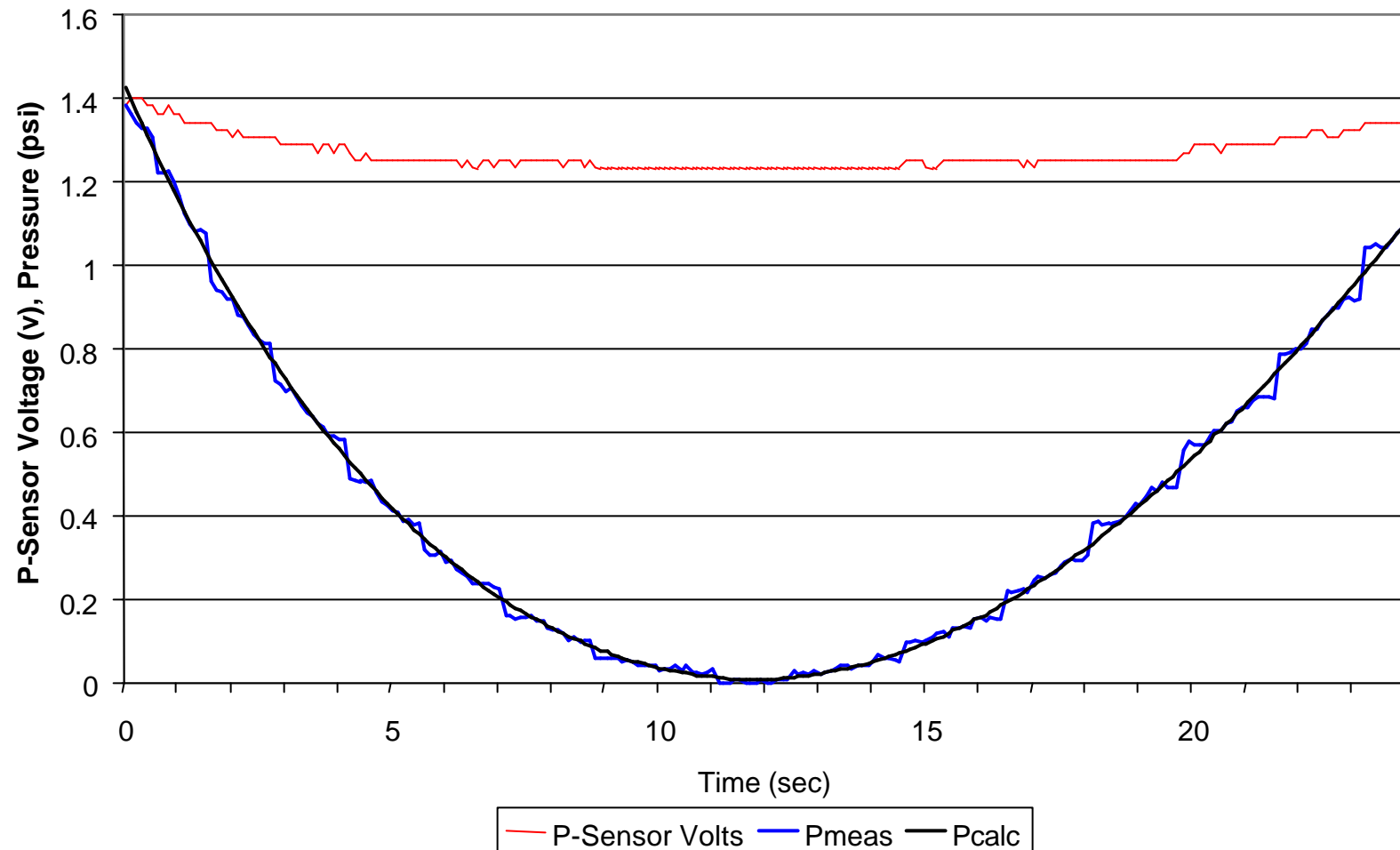


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Second Env Sensor



P-Sensor Output vs Time
60mm, Chg 1, QE85





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Safe and Arm Device

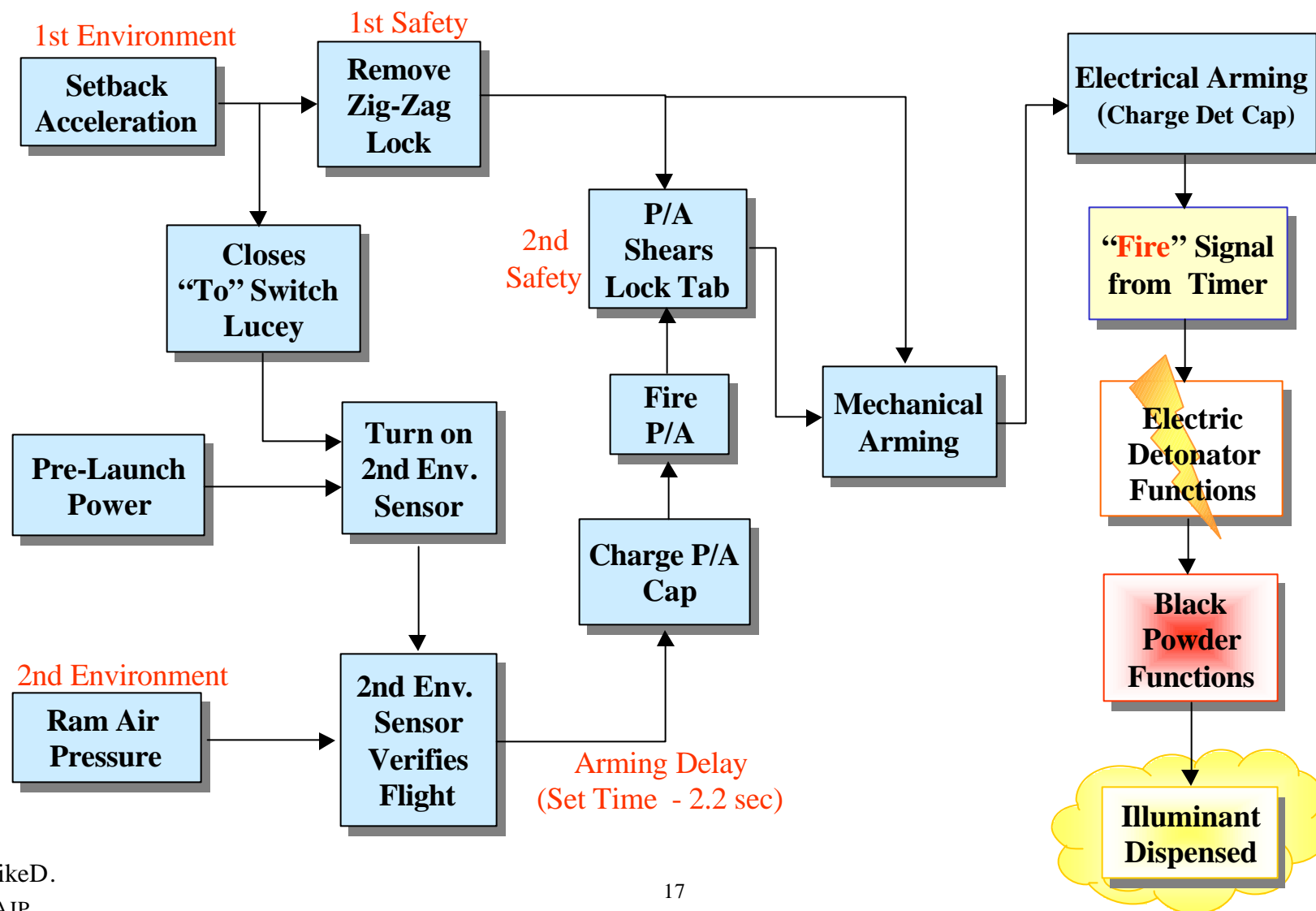


- **Design approaches:**
 - **Command arm w/ piston actuator (stored energy)**
 - **Evaluated air powered arming**
 - removing a lock then spring driven in-line
 - directly arming the fuze
- **Zig-zag setback lock with switch closure**
- **Designed both barrier and rotor approaches**
- **Develop PRO-E layout to generate SLA hardware**



Safety Logic Diagram - ET Fuze for Mortars

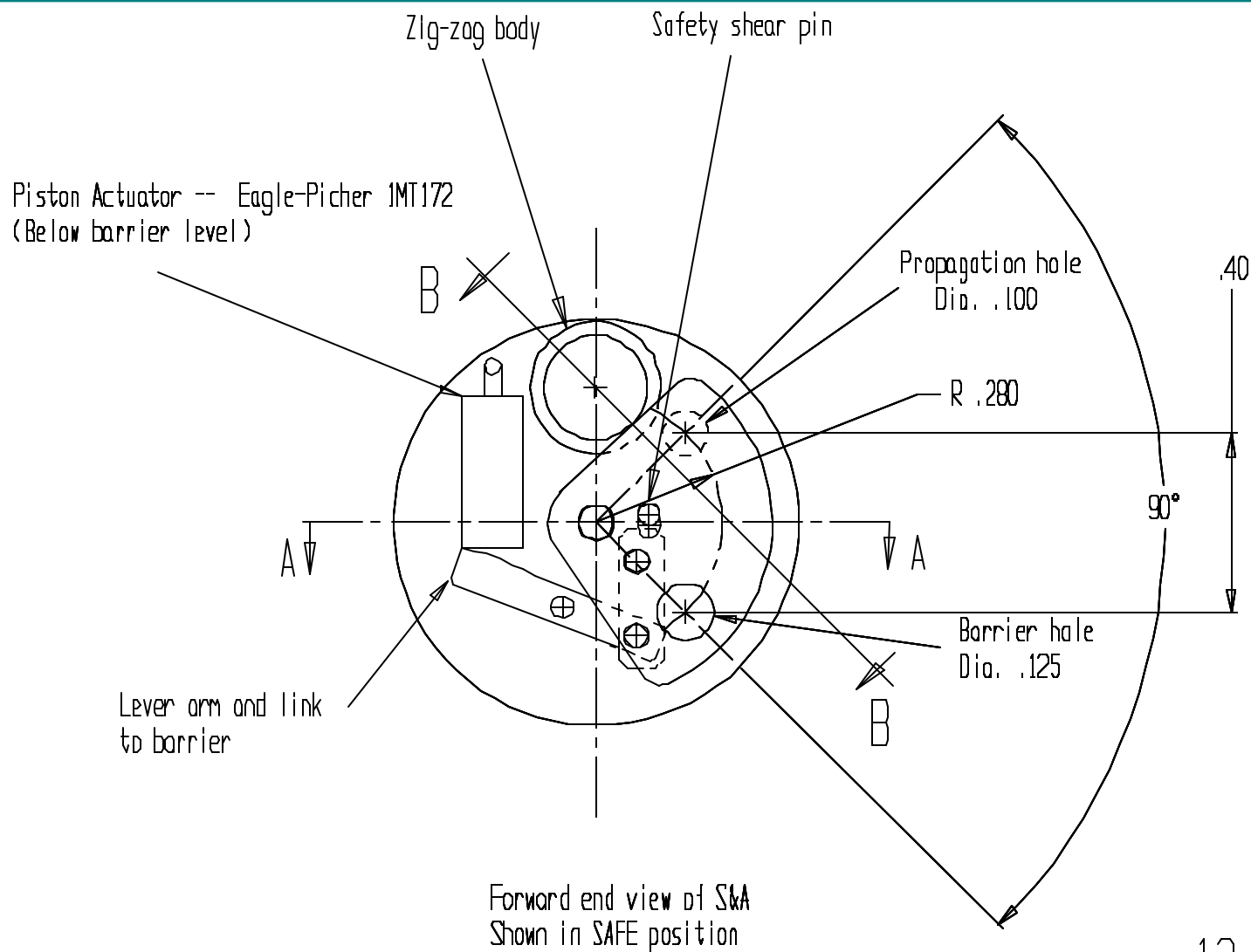
(Version B)





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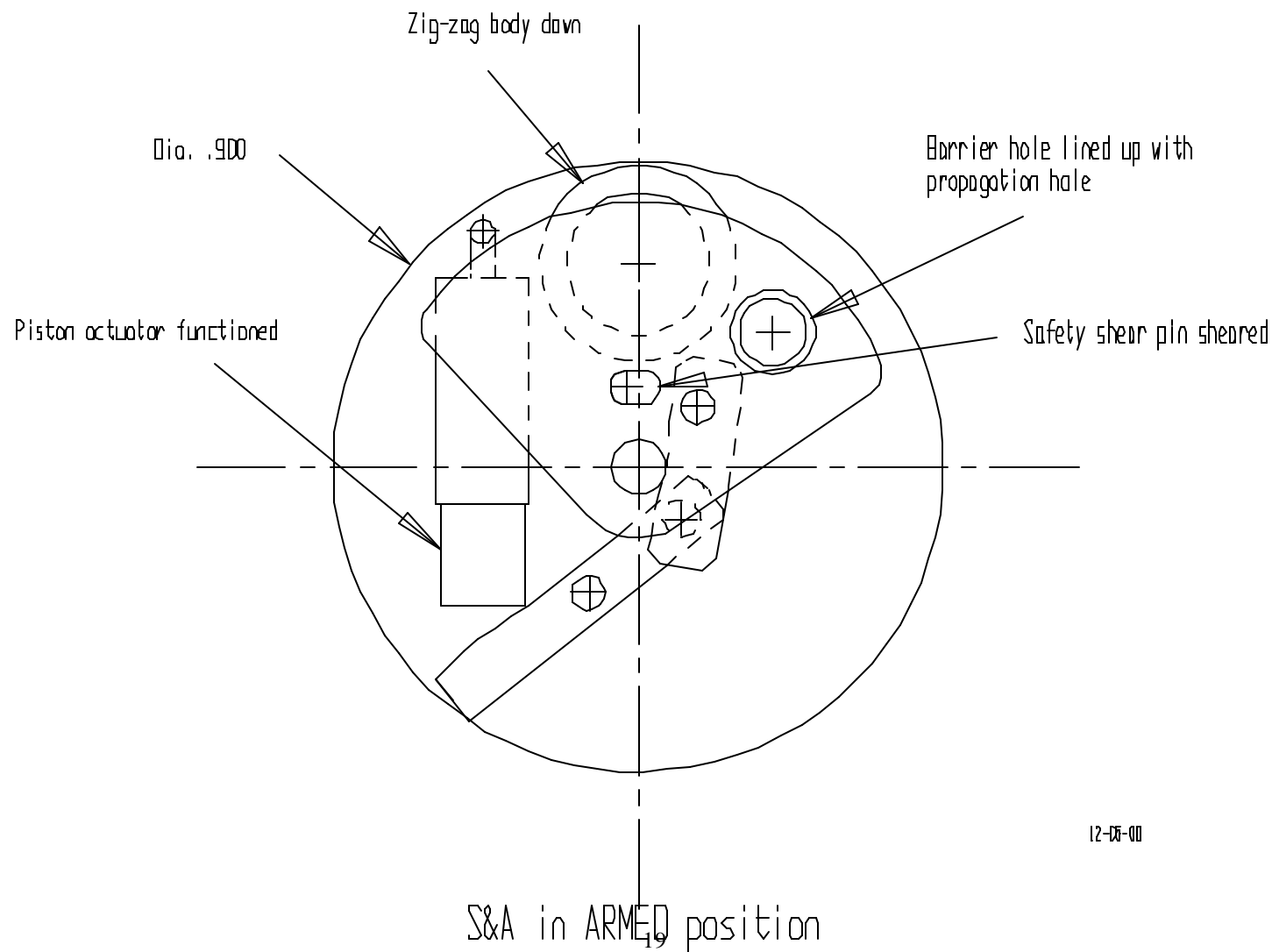
S&A (safe position)





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S&A (armed position)



XM784/ XM785 ET Fuze for Mortars *S&A (zig-zag)*

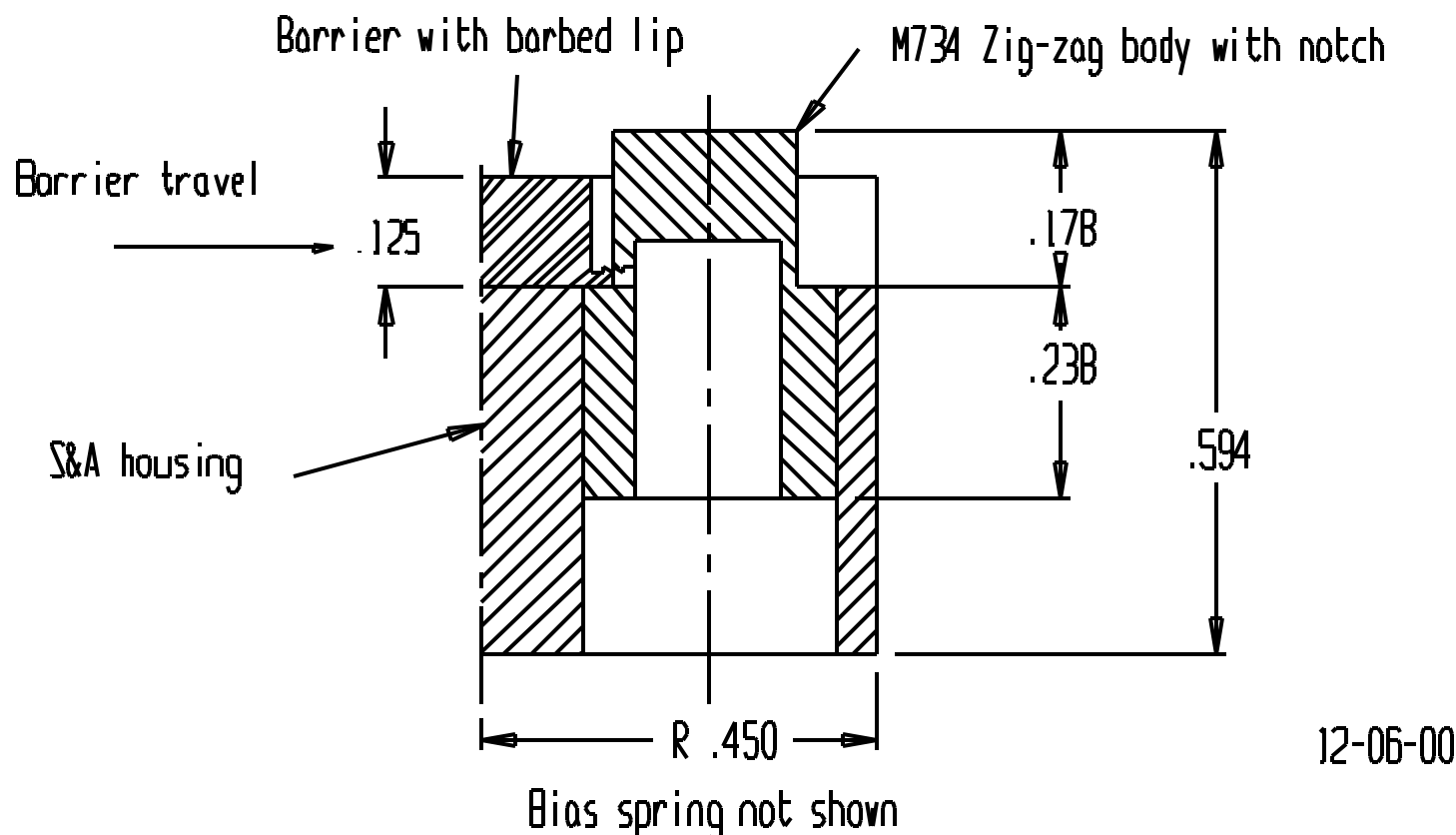


Fig. 3 Half-Section of Fail-Safe Latching Barrier
for Angular, Out-of-Plane S&A Layout



XM784/ XM785 ET Fuze for Mortars

Explosive Train



- **Utilized explosive experts**
 - **Generated a matrix of possible candidates**
- **Identified a possible on-shore source for black powder**
 - **M10 to be considered as a replacement**
- **Concepts to initiate black powder:**
 - **Electric detonator or primer initiates powder directly**
 - **Electric match initiates intermediate chg (environmental stability a concern)**
- **Conduct explosive tests with candidate initiators**



XM784/ XM785 ET Fuze for Mortars

Packaging and Hand Setting

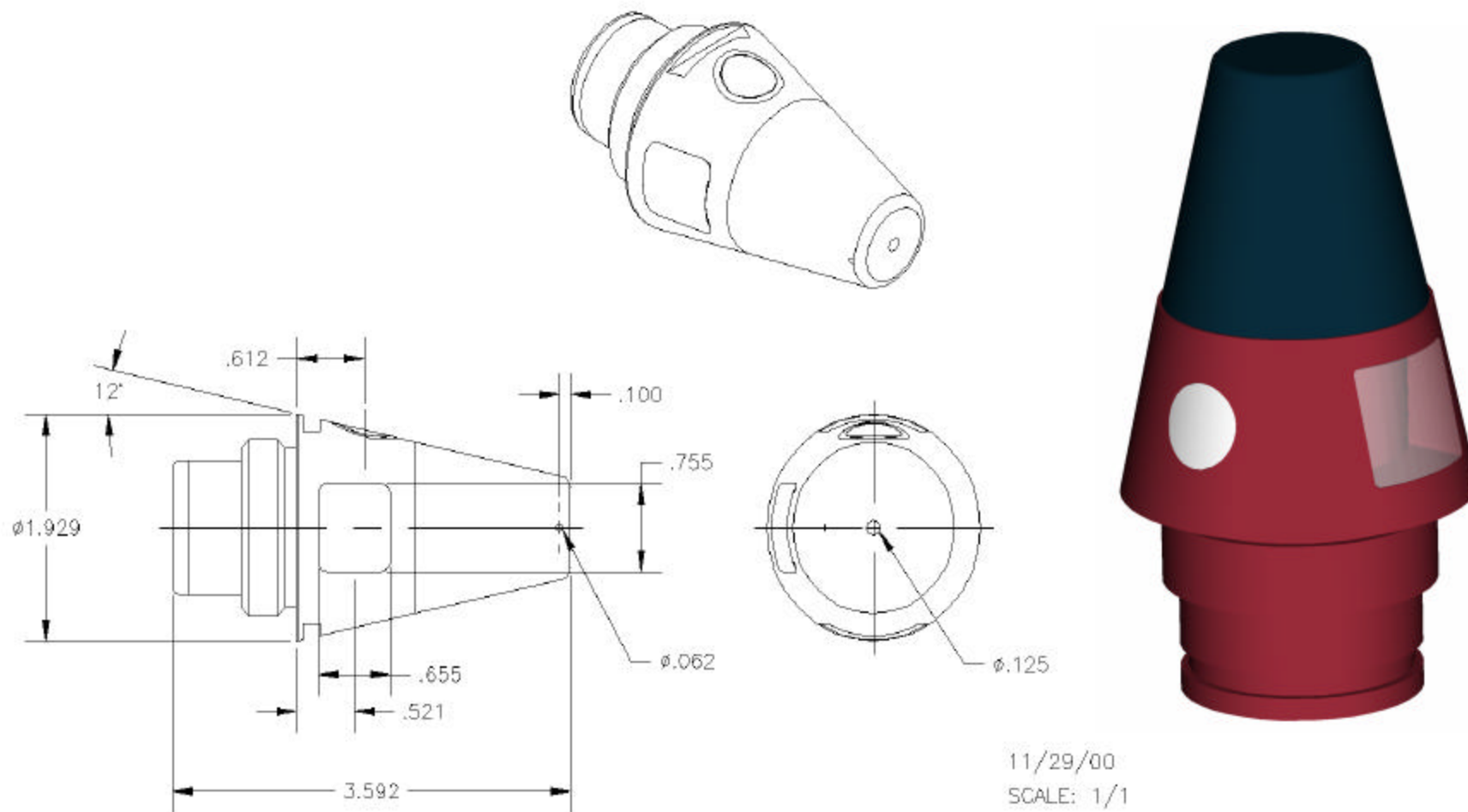


- **Generated Packaging Layouts**
 - Vertical and Horizontal Circuit Boards
 - Utilizing flex circuit concept
- **Handset scheme similar to M762**
- **Used NDI / custom LCD's (M762 Based)**
- **Developed a PRO-E model**
 - Handset concept (SLA prototype)



XM784/ XM785 ET Fuze for Mortars

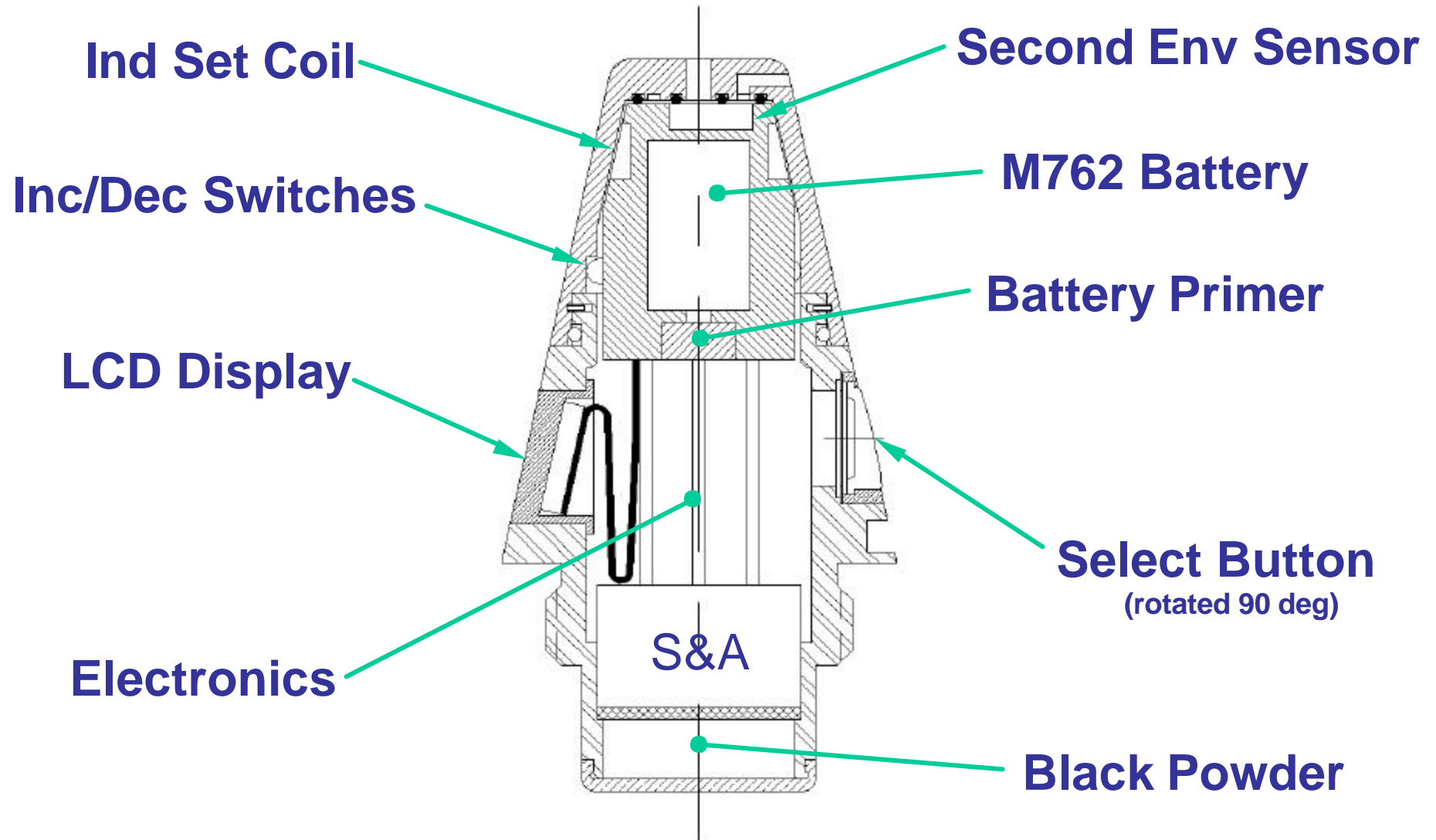
Packaging Model





XM784/ XM785 ET Fuze for Mortars

Packaging Concept





XM784/ XM785 ET Fuze for Mortars

Summary



- Planning Contract Award In June 2001
 - Design & Development
 - Test & Type Classify
 - First Article & Materiel Release
- Developed Initial In-House Design Concept
- Will Use Best (Cost Effective) Design Approach
 - Proposed Contractor Solution
 - Government Design
- Gov't Electronics Design Approach Follows....